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PROGRAM TITLE

Building T028 Decommissioning

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Building T028 Radiological Survey Procedure 3111

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ABSTRACT

Procedures are given for performing the final radiological survey of Bldg. T028 (Stir Facility). Contamination and radiation criteria for the release of the facility for unrestricted use are provided.

This document includes "red-lined" changes to the Working Copy (approved in August 1988) that was a red-line change of Document Number 173DWP000021 "RIHL Final Radiological Survey Procedure."

FORM 734-C REV. 12-84

CONTENTS

FIGURES

1.0 SCOPE

This document provides the procedures for performing the final radiological survey of Building T028 (former Stir Facility). Included are the analytical techniques to be applied to the data obtained from the survey. The survey will ensure that all NRC and State of California criteria for release of the facility for unrestricted use have been met. The overall facility description and the technical approach to the decontamination and decommissioning phase are contained in Applicable Document No. 1.

This document includes "red–lined" changes to the Working Copy (approved in August 1988) that was a red–line change of Document Number 173DWP000021 "RIHL Final Radiological Survey Procedure."

2.0 APPLICABLE DOCUMENTS AND REFERENCES

2.1 APPLICABLE DOCUMENTS

1. "Decontamination Plan for Building T028," IL, C. H. Knox to W. R. McCurnin, August 1, 1988
2. ESG 82–83, "Health and Safety Sections for Renewal Application of the Special Nuclear Materials License SNM–21, Docket 70–25, Issues to Energy Systems Group of Rockwell International," June 5, 1984
3. "Confirmatory Radiological Survey, Nuclear Materials Development Facility (T–055), Rockwell International, Santa Susana, California," July 1987
4. Federal Register, Volume 46, No. 205
5. Regulatory Guide 6.6, "Acceptance Sampling Procedures for Exempted and Generally Licensed Items Containing By–Product Material"

2.2 REFERENCES

1. "Selected Techniques of Statistical Analysis," Statistical Research Group, Columbia University, McGraw–Hill Book Co. Inc., 1947
2. "Some Theory of Sampling," W. E. Deming, Dover Publications, Inc., New York, 1950
3. "Statistics in Research," B. Ostle and R. Mensing, The Iowa State University Press, 1979

3.0 EQUIPMENT AND MATERIALS

3.1 EQUIPMENT

Ludlum Model 2220–ESG Scaler/Ratemeter

Ludlum Model 43–1 Alpha Scintillation Probe

Canberra Low–Background Alpha/Beta Counting System

Ludlum Model 44–9 Thin–Window Pancake GM Probe

Ludlum Model 44–2 High–Energy Gamma Probe

Canberra Series 80MCA System with High–Purity Germanium Detector

Note: "Or equivalent" applies to all above model numbers.

3.2 MATERIALS

Whatman 540 Filter Paper, or equivalent

Miscellaneous operating supplies

4.0 SPECIAL SAFETY PRECAUTIONS

At the time of the final survey, it is anticipated that no special safety hazards will be present.

5.0 WORK INSTRUCTIONS

A single designated "working copy" of this DWP will be utilized at the work site. Should procedure changes become necessary, the single designated "working copy" of this DWP may be red–lined (in red ink) if approved by the Nuclear Operations Manager or his designee(s). Radiation and Nuclear Safety must approve and sign any changes affecting health and safety; the Program Manager must approve and sign any changes affecting cost or schedule; and Quality Assurance must approve and sign any changes affecting quality. At the completion of the task covered by the DWP, all red–lined changes will be incorporated into this DWP and released through Technical Data Operations.

5.1 SAMPLING PLAN

For purposes of statistical analysis of the survey results, the facility will be divided into two areas. These areas are as follows:

1. Rooms 102 and 102A
2. Test vault

If contamination or high ambient radiation is found in either of these areas, the survey will be expanded into neighboring areas.

5.1.1 Walls, Floors, and Ceilings

Starting at one corner of an area, a uniform 3–m x 3–m grid shall be superimposed on the floor, walls, and ceiling. A 1–m x 1–m area within each 3–m x 3–m area shall be selected for survey. This shall be a random selection, except that, where possible, it should be biased toward that area which is expected to have had the highest contamination level. For surfaces having areas less than 3 m x 3 m, a minimum area of 1 m x 1 m shall be surveyed. A higher density of sampling grids should be used in those cases where the indicated procedure will result in fewer than about 30 total data points for statistical analysis.

5.1.2 Structural Surfaces

Structural surfaces will consist of beams, pipes, conduits, and other surfaces that are not amenable to large surface measurements. 20% of the structural surfaces shall be surveyed. The selection of surfaces to survey should again be biased toward those expected to have the highest contamination levels.

5.2 REQUIRED MEASUREMENTS AND ACCEPTANCE CRITERIA

A sampling inspection method using variables, discussed in Section 5.6.3.2, will be used to demonstrate that the residual contamination and radiation levels for each sampling area are below the following limits.

Measurement Method	Alpha (dpm/100 cm^2)*	Beta (dpm/100 cm^2)*
Total, averaged over 1 m^2	5,000	5,000
Total, maximum over 100 c^2	15,000	15,000
Removable over 100 cm^2	1,000	1,000

*Note: As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

Surfaces must also meet the following limit:

Ambient exposure rate at 1 m	5 uR/hr above background (gamma)

5.3 INSTRUMENT CALIBRATIONS AND CHECKS

Measurements of the average and maximum alpha surface activities shall be made with alpha scintillation detectors, sensitive only to alpha particles with energies exceeding about 1.5 MeV. The detectors shall be calibrated with a Th-230 alpha source standard.

Measurements of the average and maximum beta surface activities shall be made with a thin-window pancake Geiger-Mueller tube. The detectors shall be calibrated with a Tc-99 beta source standard.

Measurements of removable surface activity (alpha and beta) shall be made by wiping approximately 100 cm^2 of surface area using standard smear disks. The activity on the disks shall be measured using a gas-flow proportional counter. The counters shall be calibrated using Th-230 and Tc-99 standard sources.

The ambient exposure rate at 1 m from surfaces will be measured using a 1-in. NaI scintillation detector. These instruments shall be calibrated against a Reuter-Stokes high-pressure ionization chamber, and daily checks shall be made using an Ra-226 source placed 1 ft from the detector.

All portable survey instruments shall be serviced and calibrated on a quarterly basis. In addition, daily (when used) checks and calibrations shall be performed on all instrumentation to determine acceptable performance. All daily calibrations and checks shall be made at the beginning of the work day, at mid-day, and at the end of the work day. The average of the backgrounds and efficiency factors determined at the beginning and end of each half-day shall be used with data obtained during that time period. All calibration and check data shall be recorded on a standard health and safety instrument qualification data sheet. Acceptance limits for daily checks shall be established for each instrument at ±20% about the initial calibration value.

5.4 SURVEY PROCEDURES

In order to facilitate the average and maximum contamination measurements, the alpha and beta probes should be connected by a common faceplate so that they can be moved over the survey area as a unit.

5.4.1 Average Contamination Measurements

1. Identify the 1–m x 1–m area to be measured. If a structural surface is being surveyed, select a 2–ft section out of every 10 ft for sampling.
2. With portable scalar instrumentation set for a 5–min count time, uniformly scan the area with the alpha–beta probe combination. Watch and listen for "hot spots" where radioactivity may exceed the average limit. These are to be resurveyed later.
3. Record the location, total counts, instrument numbers, date, and time.

5.4.2 Maximum Contamination Measurements

1. Return to any area previously identified as having a "hot spot."
2. Repeat the 5–min uniform scan of only the "hot spot" area, covering approximately 100 cm^2 with the alpha–beta probe combination.
3. Record the location, total counts, instrument numbers, date, and time.

5.4.3 Removable Contamination Measurements

1. Using an NPO 2–in.–diameter cloth swipe, wipe an "S" or "Z" pattern, with legs approximately 6 in. long, so as to sample removable contamination from an area of approximately 100 cm^2 within the 1–m^2 area identified and measured with the survey meters.
2. Place the smear in an envelope kit and record the location of the sample area, date, and time on the envelope. Save until ready for counting.
3. Measure the activity of the swipe using a gas–flow proportional counter and a 5–min count time.
4. Record the location, total alpha and beta counts, instrument number, date, and time.

5.4.4 Ambient Exposure Rate Measurements

1. For each selected 1–m x 1–m survey area, position the NaI detector at a distance of 1 m from the center of the survey area.

2. Obtain a 5–min integrated count.

3. Record the location, integrated count, instrument number, date, and time.

5.5 DATA ANALYSIS

5.5.1 Conversion of Data to Activity and Radiation Units

Data that was recorded at the time measurements were made, shall be transferred to a computer spreadsheet. One spreadsheet should be created for each statistical sampling area. Columns shall be created to accept the following input data:

1. Room number
2. Grid location
3. Alpha total activity, averaged over 1 m^2 (5–min count)
4. Alpha maximum activity for "hot spot" (5–min count)
5. Alpha removable activity (5–min count)
6. Beta total activity, averaged over 1 m^2 (5–min count)
7. Beta maximum activity for "hot spot" (5–min count)
8. Beta removable activity (5–min count)
9. Ambient gamma count (5 min)
10. Alpha survey instrument background (5 min), efficiency factor (dpm/cpm), and area factor
11. Alpha gas proportional detector background (5 min) and efficiency factor (dpm/cpm)
12. Beta survey instrument background (5 min), efficiency factor (dpm/ cpm), and area factor
13. Beta gas proportional detector background (5 min) and efficiency factor (dpm/cpm)
14. Gamma survey instrument background (5 min) and efficiency factor

Columns shall then be created to calculate the following output data:

1. Alpha total activity averaged over 1 m^2 and standard deviation (dpm/100 cm^2)
2. Alpha maximum activity and standard deviation (dpm/100 cm^2)
3. Alpha removable activity and standard deviation (dpm/100 cm^2)

4. Beta total activity averaged over 1 m^2 and standard deviation (dpm/100 cm^2)
5. Beta maximum activity and standard deviation (dpm/100 cm^2)
6. Beta removable activity and standard deviation (dpm/100 cm^2)
7. Ambient gamma exposure rate and standard deviation (μR/hr)

The counts observed for the alpha and beta surface activity are converted to dpm/100 cm^2 by:

$$SA = \frac{(C - B)}{5} \text{ x } E \text{ x } \frac{100}{A}$$

where SA = surface activity (average or maximum)
C = total count in 5 min
5 = count time, min
B = background count in 5 min
E = efficiency factor, dpm/cpm
100 = 100 – cm^2 standard area
A = probe sensitive area, cm^2

Note that the analysis is done using counts rather than count rates. The standard deviation of the measurement in dpm/100 cm^2 is given by:

$$SD = \frac{\sqrt{(C + B)}}{5} \text{ x } E \text{ x } \frac{100}{A}$$

The smear activities counted by the gas–flow proportional counters for the alpha and beta removable surface activity are converted to dpm/100 cm^2 by:

$$SA = \frac{(C - B)}{5} \text{ x } E$$

where the appropriate alpha and beta background and efficiency factors are used. Standard deviations shall also be calculated.

The ambient gamma exposure rate is calculated as follows:

$$AER = \frac{C}{5} \text{ x } E$$

No adjustment for background is made. The standard deviation is then obtained as follows:

$$SD = \frac{\sqrt{C}}{5} \times E$$

After the data are entered into the spreadsheet and the calculated values are obtained, a disk file is created for storing the calculated values. A software program will then be used to read this file and to plot activities or exposure rates against the Gaussian cumulative distribution function on a probability scale. If the data follows a normal distribution, then the resulting plot is a straight line.

5.5.2 Statistical Analysis

From the plot of activity versus cumulative probability, the mean contamination value of the lot is approximately the value on the ordinate axis where the distribution intersects the 50% cumulative probability line. The distribution is analyzed in terms of sampling inspection, "inspection by variables." The test is satisfied if the Gaussian straight line passes below the intersection of the upper acceptance limit on the y–axis and approximately 93% cumulative probability on the x–axis.

The test statistic $\bar{x}$ + ks is compared to the acceptance limit U, where:

$\bar{x}$ = average (arithmetic mean of measured values)

s = observed sample standard deviation

k = tolerance factor calculated from the number of samples to achieve desired sensitivity to the test

U = acceptance limit.

The State of California has stated that the consumer's risk of acceptance (β) at 10% defective (LTPD) must be 0.1. For these choices of β and LTPD, $K_\beta = K_2 = 1.282$. The number of samples is n. Values of k for each sample size are calculated in accordance with the following equations:

$$k = \frac{K_2 + \sqrt{K_2^2 - ab}}{a}; \quad a = 1 - \frac{K_\beta^2}{2(n-1)}; \quad b = K_2^2 - \frac{K_\beta^2}{n} \qquad (1)$$

where k = tolerance factor

K_2 = the normal deviate exceeded with probability of β, 0.10 (from tables, K = 1.282)

K_β = the normal deviate exceeded with probability equal to the LTPD, 10% (from tables, K = 1.282)

n = number of samples

The criteria for acceptance are presented as a plan of action. The plan of action is:

1. Acceptance: If the test statistic ($\bar{x}$ + ks) is less than or equal to the limit (U), accept the region as clean. (If any single measured value exceeds 80% of the limit, decontaminate that location to as near background as is possible, but do not change the value in the analysis.)

2. Collect additional measurements: If the test statistic ($\bar{x}$ + ks) is greater than the limit (U), but $\bar{x}$ itself is less than U, independently resample and combine all measured values to determine if $\bar{x}$ + ks < = U for the combined set; if so, accept the region as clean. If not, reject the region.

3. Rejection: If the test statistic ($\bar{x}$ + ks) is greater than the limit (U) and $\bar{x}$ > = U, reject the region.

5.5.3 Sampling Inspection

5.5.3.1 Counting Statistics

The emission of atomic and nuclear radiation obeys the rules of quantum theory. As a result of this, one can only determine the probability that an emission will occur. If one attempts to measure the number of particles emitted by a radioactive source, that number is not constant in time; it has a statistical variation because of the probabilistic nature of the phenomenon under study. The number of particles emitted per unit time is different for successive units of time. Therefore, one can only determine the average number of particles emitted per unit time and per unit area. Because of the probabilistic nature of particles emitted by radioactive elements, repeated measurements of the average number of emissions per unit time will show a distribution approximated by the Gaussian (or normal) probability density function (pdf). If measurements are made at many similar locations in a homogeneous set, these measurements will generally show a somewhat greater variability, but the distribution will remain adequately represented by a Gaussian function. Thus, the number of occurrences of particular contamination values, f(x), shows a Gaussian pdf relative to the contamination value, and the data can be plotted accordingly. Subsequently, based on the results of the data analysis, a conclusion can be made regarding the level of residual contamination in the building.

The Gaussian distribution, g(x), is given by:

$$g(x)dx = \frac{1}{(\sqrt{2\pi})\sigma} \exp\left[-\frac{(x-m)^2}{2\sigma^2}\right] dx$$

where g(x)dx = probability that the value of x, the measured value, lies between x and x + dx

m = average or mean of the distribution

σ^2 = variance of the distribution

A graph of g(x) versus x gives the following bell-shaped curve:

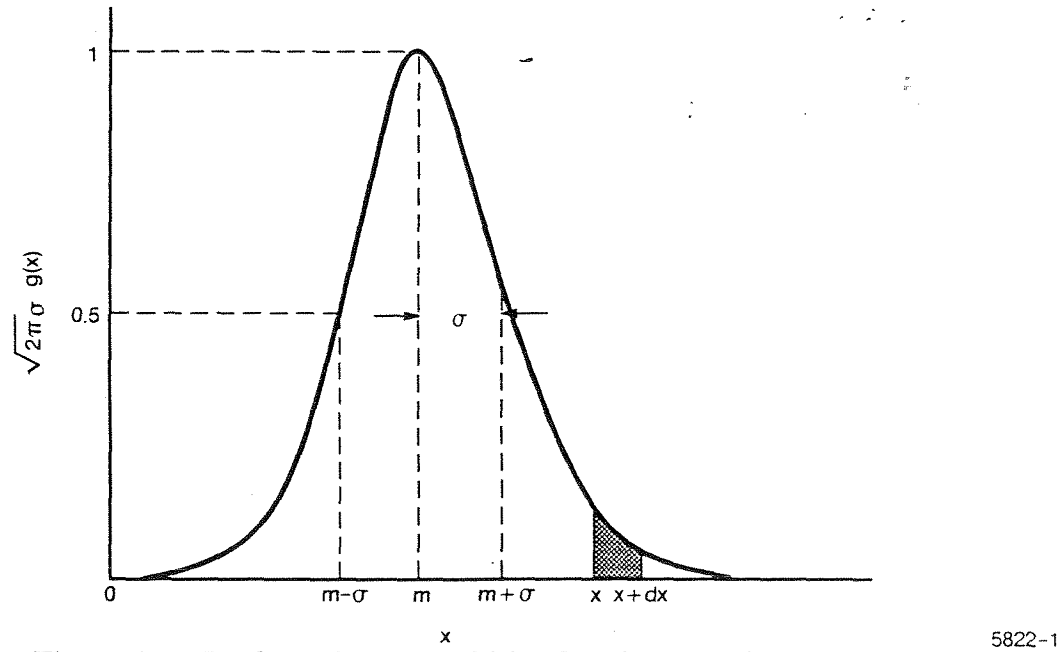

Figure 1. The Gaussian Probability Density Function

Furthermore, the cumulative distribution function (cdf), G(x), (equal to the integral of the pdf, for a continuous random variable) is:

$$G(X) = \int_{-\infty}^{X} g(x)dx$$

$$= P(x <= X)$$

This function is commonly referred to as the error function (erf). The graph of the Gaussian cdf is:

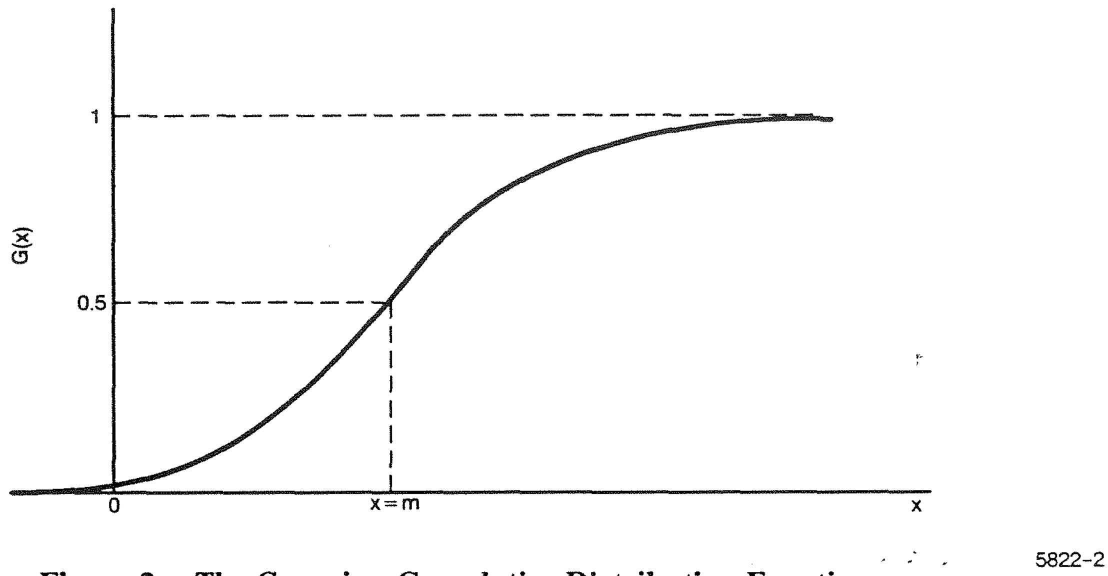

Figure 2. The Gaussian Cumulative Distribution Function

If x is the survey measurement (in the case of radiation measurements, the number of counts), the standard deviation of the measurement is the square root of x. Background radiation must also be considered to calculate the net number of counts. Thus, the error, or standard deviation associated with the measurement, becomes:

$$S = \frac{\sqrt{C + B}}{T}$$

where C = the number of counts recorded in time, T, of the sample

B = the number of counts recorded in time, T, of the background radiation environment

T = time of count, assumes the sample count time is equal to the background discount time

Finally, corrections must be made for instrumentation parameters including geometry and efficiency.

5.5.3.2 Sampling Inspection by Variables

Acceptance inspection by variables is a method of judging whether a lot of items is of acceptable quality by examining a sample from the lot, or population. In the case of determining residual contamination in the RIHL, it would be unacceptably time consuming and not cost effective to measure and document 100% of the building. However, by applying sampling inspection by variables methods, acceptable confidence in the conclusion made about the level of contamination can be achieved.

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In acceptance inspection by attributes, the radiation measurement in a given area is recorded numerically and classified as either being defective or nondefective, according to regulatory acceptance criteria. A defect means an instance of a failure to meet a requirement imposed on a unit with respect to a single quality characteristic. Second, a decision is made from the number of defective areas in the sample whether the percentage of defective areas in the lot is small enough for the lot to be considered acceptable. In acceptance inspection by variables, the result is recorded numerically and is not treated simply as a Boolean statistic, so fewer areas need to be inspected for a given degree of confidence in judging a lot's acceptability.

The test statistic, $\bar{x} + ks$, is compared to the acceptance limit U,

where $\bar{x}$ = average (arithmetic mean of measured values)

s = observed sample standard deviation

k = tolerance factor calculated from the number of samples to achieve the desired sensitivity for the test

U = acceptance limit

The sample mean, standard deviation, and acceptance limit are easily calculable quantities; the value of k, the tolerance factor, bears further discussion. Of the various criteria for selecting plans for acceptance sampling by variables, the most appropriate is the method of Lot Tolerance Percent Defective (LTPD), also referred to as the Rejectable Quality Level (RQL). The LTPD is defined as the poorest quality that should be accepted in an individual lot. Associated with the LTPD is a parameter referred to as consumer's risk (β), the risk of accepting a lot of quality equal to the LTPD. USNRC Regulator Guide 6.6 ("Acceptance Sampling Procedures for Exempted and Generally Licensed Items Containing By–Product Material") states that the value for the consumer's risk should be 0.10. Conventionally, the value assigned to the LTPD has been 10%. These a–priori determinations are consistent with the literature and regulatory position and are the same values used by the State of California. Thus, based on sampling inspection, we are willing to accept the hypothesis that the probability of accepting a lot as not being contaminated which is, in fact, 10% defective is 0.10. The value of k, which is a function

The coefficients K_2 and K_β are equal because of the choice for the values of β and LTPD as 0.10. Statistics textbooks listed in the References 1 through 3 provide additional explanation of this sampling principle. The a-priori values chosen for the sampling coefficients are consistent with industrial sampling practice and regulatory guides.

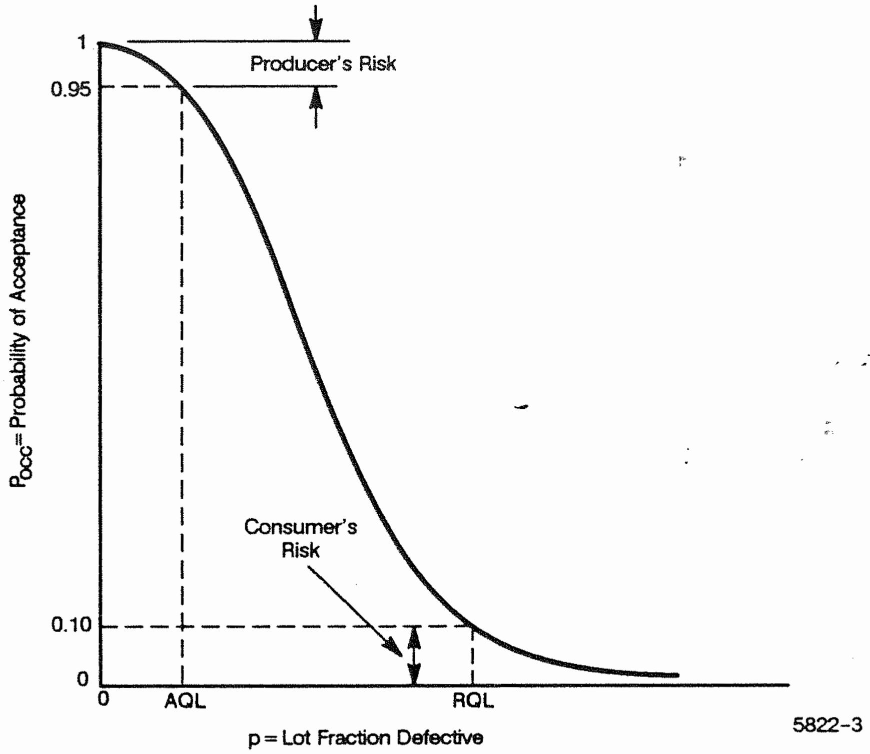

Figure 3. Operating Characteristics Curve

6.0 WASTE VOLUME ESTIMATES

Not applicable.

7.0 MANPOWER ESTIMATES

	EP	Total Man-Hours
Rockwell Final Survey		
D/641, health physics technicians	1.0	60
D/641, engineers	0.8	48
D/641, management	0.1	6
		114

8.0 PERSONNEL RADIOLOGICAL ESTIMATES

Not applicable.